BRADLEYITE, A NEW MINERAL, SODIUM PHOSPHATE-MAGNESIUM CARBONATE[1]

JOSEPH J. FAHEY,
Geological Survey, Washington, D. C.,
with
X-ray Analysis
by
GEORGE TUNELL,
Geophysical Laboratory, Carnegie Institution of Washington, Washington, D. C.

ABSTRACT

An anisotropic fine grained mineral, associated with shortite and carbonaceous clay, was found in the drill core of the John Hay Jr. Well No. 1 in Sweetwater County, Wyoming, at a depth of 1342′10″. It has been named bradleyite in honor of Dr. W. H. Bradley of the Geological Survey. Chemical analysis shows that the formula is $Na_3PO_4 \cdot MgCO_3$. *X*-ray powder diffraction photographs of bradleyite made with filtered copper K-radiation show that it does not contain $MgCO_3$ in the form of magnesite. The spacings and intensities of the lines of the *x*-ray powder photograph of bradleyite are tabulated to aid in its future identification.

INTRODUCTION

A second new mineral has been found in the oil shale of the drill core of the John Hay Jr. Well No. 1 from which shortite,[2] $Na_2Ca_2(CO_3)_3$, was obtained and recently described. This well, in the Green River formation, is on government land about 20 miles west of the city of Green River, Sweetwater County, Wyoming. Because of the unusual association of minerals found in these shales, the writer visited the area in the summer of 1939 and through the courtesy of the Mountain Fuel Supply Company was able to obtain about 500 feet of the drill core containing the saline minerals in the shale. This is now being examined critically and carefully logged throughout its length.

Bradleyite was found as a layer an inch thick at a depth of 1342′10″. The other saline minerals in the drill core so far determined are trona, shortite, pirssonite, gaylussite, bromlite, and northupite. Montmorillonite, quartz, dolomite, and pyrite are also present. The new mineral is named bradleyite in honor of Dr. Wilmot H. Bradley of the Geological Survey, U. S. Department of the Interior, whose many years of productive geologic investigation in this area well merit this recognition.

[1] Published by permission of the Director, Geological Survey, U. S. Department of the Interior, Washington, D. C.

[2] Fahey, J. J., Shortite, a new carbonate of sodium and calcium: *Am. Mineral.*, **24**, 514–518 (1939).

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Occurrence

The one-inch layer of very fine grained bradleyite contains about 30 per cent of much coarser shortite, and 10 per cent of clay (montmorillonite). The clay contains organic matter which yields oil when heated in a closed tube. A thin section shows that the crystals of shortite have been partly replaced by bradleyite. Above the bradleyite, the core consists essentially of shortite and northupite with a little clay; below the bradleyite, it consists of brown clay which contains about 40 per cent of shortite and 20 per cent of northupite. In both parts of the core the northupite is later than the shortite.

Physical Properties

The bradleyite is extremely fine grained. Hardly any grain, extinguishing as a unit, as seen in thin section under high magnification, is more than 0.002 mm. across. The birefringence is strong. Only the extreme indices of refraction could be measured, α being about 1.49 and γ about 1.56, hence the birefringence is about 0.07.

The mean index of refraction of the clay is about 1.555, that of the bradleyite mixed with clay is 1.530. Taking into consideration the relative proportions of bradleyite and clay in the mixture (85 and 15 per cent respectively), by computation the mean index of bradleyite is probably close to 1.525.

The light-gray color of the sample is probably due to the admixed darker clay, pure bradleyite being probably white or colorless.

The specific gravity of the sample analyzed, determined with a pycnometer, using toluol, is 2.646. That of the clay, determined in the same way, is 2.141. From these values and the percentage of clay in the bradleyite sample, the specific gravity of pure bradleyite was calculated to be 2.734. By applying the Gladstone Dale equation a good check on the specific gravity was obtained with the figure 2.725.

No value for hardness could be obtained.

X-ray Analysis by George Tunell

X-ray powder diffraction photographs were made of natural bradleyite mixed with 15 per cent of oil shale with use of copper K-radiation filtered through nickel foil, and for comparison, diffraction photographs were made in the same camera, also with use of copper K-radiation filtered through nickel foil, of the oil shale from which the bradleyite had been removed by solution, and also of magnesite. The next strongest line of the oil shale pattern is not present at all on the films of bradleyite mixed with 15 per cent of oil shale, and the strongest line of the oil shale pattern if present at all merely adds very slightly to a strong line of bradleyite with which it is almost coincident. The remaining lines of the oil shale pattern are not visible on the powder photograph of bradleyite.

The lines of the powder diffraction pattern of bradleyite are listed in Table 1. The intensities were estimated visually on a scale of ten, where

TABLE 1. PLANAR SPACINGS AND RELATIVE INTENSITIES OF THE DIFFRACTION LINES IN THE X-RAY POWDER SPECTRUM OF BRADLEYITE

(Filtered CuK-radiation) Spacing	Intensity	(Filtered CuK-radiation) Spacing	Intensity
8.939Å	3	1.598Å	½
3.680	5	1.562	3
3.319	10	1.494	4
2.969	2	1.443	3
2.658	10	1.385	4
2.566	8	1.331	2
2.467	½	1.288	2
2.388	½	1.251	1
2.313	½	1.224	½
2.209	3	1.186	1 (broad)
2.116	4	1.151	2
2.025	½	1.101	3
1.935	4	1.068	2
1.842	8	1.038	1
1.760	½	1.011	½
1.704	½	0.987	½
1.658	6		

ten represents the intensity of the strongest line. Several powder diffraction photographs of bradleyite mixed with 15 per cent oil shale were made and one of bradleyite and oil shale mixed with sodium chloride. The spacings of the bradleyite lines were determined by comparison with the sodium chloride lines on the latter film.

The powder photographs of bradleyite and magnesite were compared to establish the fact that bradleyite is not composed of a mixture of magnesite and some other compound; there is no line on the powder photograph of bradleyite corresponding to the strongest line of the magnesite pattern; hence, the presence of any substantial proportion of magnesite in bradleyite is excluded. There is no reason to suppose from the evidence of the x-ray photographs that bradleyite is a mixture.

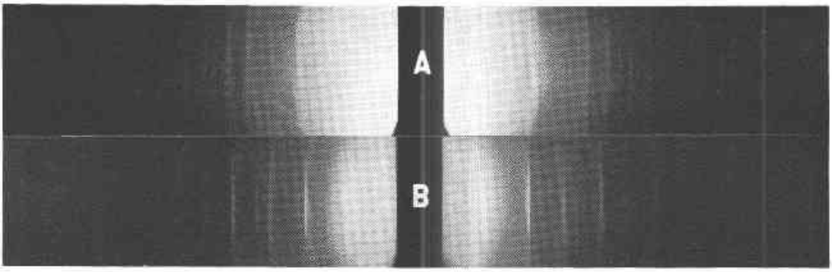

FIG. 1. *X*-ray powder photographs of (A) bradleyite and (B) magnesite taken with filtered copper K-radiation.

CHEMICAL COMPOSITION

Part of the one-inch layer of bradleyite was crushed, care being taken to avoid as much as possible the formation of fines. The crushed material was then sieved and that portion passing 60 mesh and retained on 100 mesh was passed through the Frantz isodynamic magnetic separator by which means most of the shortite was removed. The final sample (about 15 grams) was estimated by microscopic examination to contain less than one per cent of shortite. It was not possible to remove the clay so the sample analyzed consisted of about 85 per cent of bradleyite, 14 per cent of clay, and one per cent of shortite.

Bradleyite is very slowly decomposed by cold water, only a few per cent of sodium carbonate going into solution when allowed to stand over night. Water was determined by loss in both the sample analyzed and in the separated clay, and properly allocated. The bradleyite was dissolved, by treatment for one minute with cold ten per cent hydrochloric acid solution, leaving a residue of clay. The clay was filtered off, air dried, and weighed. The other constituents were obtained in the filtrate.

ANALYSIS OF BRADLEYITE

Clay	14.46
MgO	12.91
Na_2O	31.62
P_2O_5	22.03
CO_2	15.80
Fe_2O_3	0.52
Al_2O_3	0.24
CaO	0.36
SO_3	0.46
Cl	0.35
SiO_2	0.02
H_2O below 100° C.	0.30
H_2O above 100° C.	None
K_2O	None
	99.07

Computation of Formula

The CaO (0.36%) found in the analysis was considered to have come from the shortite present and the Na_2O and CO_2 equivalents were deducted before computing the formula. In the sample no minerals containing chlorine or sulfate were observed. Hence the fractional percentages of these constituents were not applied as corrections in the computations.

	Per cent	Molecular ratios
Na_2O	31.42	0.507=3.04
MgO	12.91	0.323=1.93
P_2O_5	22.03	0.155=0.93
CO_2	15.38	0.350=2.10

Formula: $3Na_2O \cdot 2MgO \cdot 2CO_2 \cdot P_2O_5$ or $Na_3PO_4 \cdot MgCO_3$ or $Na_3MgCO_3PO_4$.

In the absence of morphologic evidence the proof that bradleyite is a compound and not a mixture rests chiefly on the chemical and *x*-ray data. Tunell has shown that there is no magnesite in the sample of bradleyite that was analyzed. The low solubility of bradleyite in water (less than 5 per cent in 20 hours) rules out the possibility that either sodium phosphate or sodium carbonate may be present as separate compounds; furthermore, the simple atomic ratios indicate the existence of a definite compound.